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AUTISM SUPPORT SYSTEM

INTEGRATING FACIAL RECOGNITION, GESTURE RECOGNITION, AND EMOTIONAL GAMING FOR CHILDREN WITH AUTISM

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Abstract: The Autism Support System aims to enhance the learning and emotional development of children diagnosed with autism through innovative technologies. The emotion recognition module detects and classifies emotions from facial expressions, providing audio feedback and maintaining logs of detected emotions. In cases of frequent distress detection, an emergency SMS is sent to parents. The hand gesture recognition module enables children to play songs based on their facial expressions, fostering a multimodal interaction experience. The emotion gaming module engages children in interactive games that promote the recognition and understanding of emotions. This paper presents the system's architecture, design, implementation, and testing, along with the results and potential future improvements. The study demonstrates the potential of leveraging advanced technologies to support the emotional and social development of children with autism, offering a promising tool for therapists, educators, and caregivers. By integrating facial recognition, gesture recognition, and emotion-based gaming, the system provides a comprehensive platform for emotion detection and interaction.. This review aims to not only become a reference for future research on emotion recognition, but also to provide an overview of the work done in this topic for potential readers**.**

Index Terms **-** Autism, Facial Recognition, Gesture Recognition, Emotion Gaming, Emotion Detection, Assistive Technology

I. INTRODUCTION

1.1 Autism Spectrum Disorder (ASD)

Autism Spectrum Disorder (ASD) is a developmental disorder that affects communication, behaviour, and social interactions. It is a neurodevelopmental disorder that is characterized by abnormalities in the brain, leading to difficulties in social interaction and communication, as well as learning and attention. Early diagnosis of ASD is challenging as it mainly relies on detecting abnormalities in brain function, which may not be evident in the early stages of the disorder. Facial expression analysis has shown promise as an alternative and efficient solution for early diagnosis of ASD, as children with ASD often exhibit distinctive patterns that differentiate them from typically developing children. Children with autism often struggle with recognizing and expressing emotions, which can lead to social isolation and anxiety. These emotional and social challenges can significantly impact their daily lives, making it difficult to form relationships, succeed in school, and engage in everyday activities.

1.2 Autism and Emotions

Children with autism frequently experience difficulties in understanding and interpreting emotions, both in themselves and others. This can result in heightened levels of stress, anxiety, and frustration. Traditional therapeutic methods often require extensive, one-on-one interaction with specialists, which may not be accessible to all families. Therefore, there is a pressing need for innovative approaches that can assist in the emotional development of children with ASD.

1.3 Role of Technology in ASD:

Advancements in technology have opened new avenues for supporting individuals with autism. Technologies such as facial recognition, gesture recognition, and interactive gaming offer promising tools for enhancing emotional and social skills. These technologies can provide consistent, engaging, and personalized support, making therapy more accessible and effective.

1.4 Autism Support System

This project presents an Autism Support System designed to assist children with autism in recognizing and managing emotions through advanced technologies. By integrating and developing facial recognition for emotion detection, gesture recognition for interaction, and emotional gaming for learning, the system aims to provide a comprehensive platform that addresses multiple aspects of emotional and social development.

1.5 Modules of the Project include:

1. **Emotion Recognition:** This module detects and classifies emotions based on facial expressions. It provides audio feedback to the user, changes colour of the bounding box accordingly, and maintains logs of the detected emotions for further supervision. In cases of frequent distress detection, the system sends an emergency SMS to parents, ensuring timely intervention.
2. **Hand Gesture Recognition:** This module allows children to interact with the system using hand gestures. Based on their facial expressions, children can play songs, creating a multimodal interaction experience that is both engaging and therapeutic.
3. **Emotion Gaming:** This module incorporates interactive games designed to help children recognize and understand emotions. The games provide a fun and educational way to practice emotional recognition and expression, which can translate into improved social interactions in real life.

By combining these three components, the Autism Support System aims to create a holistic and engaging environment that supports the emotional and social development of children with autism. This paper presents the system's architecture, design, implementation, and testing, along with the results and potential future improvements, demonstrating the potential of leveraging advanced technologies to support children with ASD.

1.6 Objectives of the Autism Support System

● Timely Intervention: To provide early and appropriate emotional support which can significantly improve the quality of life for individuals with ASD.

● Enhanced Social Skills: To help in developing better social and communication skills.

● Improved Mental Health: To provide psychological support and coping strategies that can reduce anxiety and improve overall mental well-being.

● Independence: to provide tools and technologies that assist in emotion recognition and can foster greater independence and self-awareness.

● Personalized Support: To provide tailored feedback and suggestions to meet individual needs and preferences.

1.7 Scope

The "Autism Support System" project aims to provide a comprehensive support framework for individuals with autism. The system integrates multiple advanced technologies to offer personalized and effective assistance. The scope of the project includes:

1.7.1 **Autism Support System**

Functionality: Captures real-time video, analyses facial expressions with deep learning models, and provides immediate feedback and suggestions.

1.7.2 **Gesture Recognition**

Functionality: Uses computer vision techniques to detect and classify gestures, enabling interactive and supportive engagement.

1.7.3 **Visual Games**

Functionality: Offers a variety of educational games that adapt to user performance, providing a personalized and engaging learning experience.

1.7.4 **Autistic Support**

Functionality: Integrates emotion and gesture recognition with personalized feedback to support emotional well-being and social skills.

1.7.5 **Child Emergency Support**

Functionality: Detects frequent distress emotions and sends SMS notifications to caregivers, ensuring immediate support when needed.

1.7.6 **Emotion Logistics**

Functionality: Maintains a detailed log of detected emotions, providing insights for personalized recommendations and ongoing support.

II. LITERATURE REVIEW

Initial research on automatic facial detection was documented by Bledsoe in 1960, focusing on facial feature recognition for the US Department of Defence. Kanade developed the first effective autonomous facial recognition system, capable of measuring 16 distinct facial features by discriminating between machine-retrieved and human-derived features. Studies like Baron-Cohen et al. (2009) demonstrated teaching emotions to autistic children using visual clues, including movies and games. Cheng et al. (2002) provided a web application platform for autistic children to interact with simulated models. The AURORA project employed a robot to facilitate interaction between children and robots, as described by Goldsmith and LeBlanc (2004). Introduced by Ekman and Friesian, **Facial Action Coding System (FACS)** quantitatively measures and records facial expressions based on facial muscular activity. Recent advancements include the use of **deep convolutional neural networks (DCNNs**) for emotion recognition. Studies like Pantic and Rothkrantz (2000) reviewed automatic facial recognition technologies and their applications, recognizing six fundamental facial expressions or variations thereof. Assistive technologies range from basic pictorial cards to advanced human-computer interaction devices, such as robots and augmented reality applications. Technologies like Augmented and Alternative Communication (AAC) systems provide significant support in enhancing communication abilities for individuals with ASD.[1]

Autistic individuals often struggle with interpreting emotions from facial expressions. Studies have shown that using technology to teach and recognize emotions can aid in improving social interactions. Implementing systems that provide real-time feedback and interaction, such as emotional hearing aids and interactive robots, can offer therapeutic benefits for children with autism. Studies have implemented various pre-trained models like MobileNet, Xception, and Inception V3 to detect autism and recognize emotions with high accuracy. For instance, Ahmed et al. (2022) reported accuracies of 95%, 94%, and 89% for MobileNet, Xception, and

Inception, respectively[1][2]. Transfer learning techniques have been utilized to improve emotion recognition accuracy. Sadik et al. achieved 89% accuracy using a transfer learning approach with MobileNet. Nagy et al. (2021) compared the accuracy of recognizing emotions in autistic children and neurotypical children. The study found that autistic children were less accurate in identifying emotions like surprise and anger under both timed and non-timed conditions.[1]

Convolutional Neural Networks (CNNs) have become the cornerstone of image recognition tasks, including facial emotion detection. Their ability to automatically and adaptively learn spatial hierarchies of features makes them particularly suited for emotion recognition in images.

Different CNN architectures have been utilized for emotion recognition, including:

- **MobileNet**: Designed for mobile and embedded vision applications, MobileNet models are efficient and can be used in real-time applications. Studies have shown MobileNet achieving high accuracy in emotion detection tasks.[1]
- **Xception**: An extension of the Inception architecture, Xception employs depth wise separable convolutions, leading to improved model performance and efficiency. In emotion recognition tasks, the Xception model has demonstrated superior accuracy and generalization capabilities compared to other models.[1]
- **Inception V3**: Known for its balance between accuracy and computational efficiency, Inception V3 has been used to detect autism and recognize emotions with notable accuracy.[1]

- **Model Performance**: Various studies have reported on the performance of CNN models in emotion recognition:
  - **Accuracy**: CNN models like MobileNet, Xception, and Inception V3 have achieved high accuracy rates in detecting emotions from facial expressions, with Xception often leading in performance. For example, Ahmed et al. (2022) reported accuracies of 95% for MobileNet, 94% for Xception, and 89% for Inception V3[1].
  - **Feature Extraction**: CNNs are adept at extracting hierarchical features from facial images, making them highly effective for distinguishing between subtle differences in facial expressions.[2]
  - **Transfer Learning**: Transfer learning techniques have further enhanced the performance of CNN models. By leveraging pre-trained models on large datasets like ImageNet, researchers have achieved improved accuracy and robustness in emotion recognition tasks.[3]

2.1 Existing System

Existing System Overview: The current systems aimed at supporting individuals with autism often include traditional methods such as therapy sessions, specialized education programs, and manual monitoring by caregivers. Some technological interventions exist but are typically isolated, lacking comprehensive integration and real-time responsiveness.

Drawbacks of Existing System:

●Limited Automation: Existing systems largely rely on manual intervention, which can be time-consuming and less efficient.

●Lack of Real-Time Support: Many current solutions do not offer real-time emotional and gesture recognition, which is critical for immediate support.

●Fragmented Solutions: Available technologies often address individual aspects such as visual games or emotion recognition but do not provide a holistic support system.

●Accessibility Issues: High costs and limited accessibility can prevent many individuals from benefiting from existing advanced support technologies.

●Data Utilization: Insufficient use of data analytics for personalized feedback and improvements in care strategies.

2.2 Proposed System

Proposed System Overview: The Autism Support System integrates emotion recognition, gesture recognition, visual games, and personalized feedback to provide comprehensive and real-time support for individuals with autism. The system uses advanced technologies to enhance the effectiveness and accessibility of support services.

Advantages of the Proposed System:

●Real-Time Emotion and Gesture Recognition: Immediate identification and interpretation of emotions and gestures facilitate timely support.

●Integrated Support: Combines multiple functionalities such as emotion recognition, visual games, and emergency notifications into a single cohesive system.

●Personalized Feedback: Utilizes logged data to provide tailored feedback and suggestions, enhancing individual support.

●Automated Monitoring: Reduces the need for constant manual oversight, freeing up time for caregivers while ensuring continuous support.

●Accessibility and Cost-Effectiveness: Leverages common hardware (webcams, computers) and open-source software to make advanced support more accessible and affordable.

III. IMPLEMENTATION AND EVALUATION

3.1 Dataset Description

The data consists of 48x48 pixel grayscale images of faces. The faces have been automatically registered so that the face is more or less centred and occupies about the same amount of space in each image.
The task is to categorize each face based on the emotion shown in the facial expression into one of seven categories (0=Angry, 1=Disgust, 2=Fear, 3=Happy, 4=Sad, 5=Surprise, 6=Neutral).
The training set consists of 28,709 examples and the public test set consists of 3,589 examples.

Fig 3.1: Data Set Image

3.2 Software Requirement Specifications (SRS)

Functional Requirements:

●Emotion Recognition: The system must capture video input, detect faces, and accurately recognize and log emotions in real time.
●Gesture Recognition: The system should detect and interpret predefined gestures to aid communication.
●Visual Games: Interactive games must be included to support cognitive and motor skills development.
●Emergency Notifications: The system must send SMS notifications to predefined contacts when distress is detected frequently.
●Data Logging: Emotions and timestamps must be logged for further analysis and personalized feedback.

Non-Functional Requirements:

●Performance: The system should process video input and provide feedback in real time with minimal latency.
●Usability: The interface should be user-friendly and accessible, with clear instructions and easy navigation.
●Reliability: The system must be robust, with minimal downtime and reliable operation.
●Scalability: The architecture should support future enhancements and additional functionalities.
●Security: User data, especially sensitive information, must be securely handled and protected from unauthorized access.

Software Requirements:

●Operating System: Windows, macOS, or Linux
●Programming Language: Python 3.x
●Libraries and Frameworks: OpenCV, TensorFlow/Keras, pyttsx3, Twilio, NumPy
●Development Environment: Visual Studio Code, Jupyter Notebook
●Version Control: Git/GitHub

This comprehensive analysis outlines the scope, advantages, applications, and detailed software requirements for the Autism Support System, providing a solid foundation for development and deployment.

3.3 Phases of the model

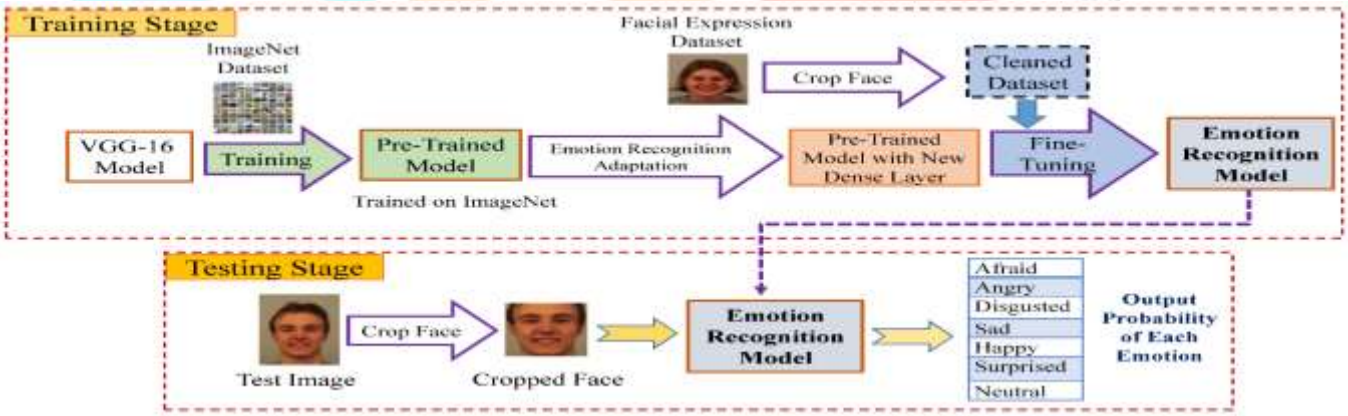

Fig 3.2: Training to Testing Phase

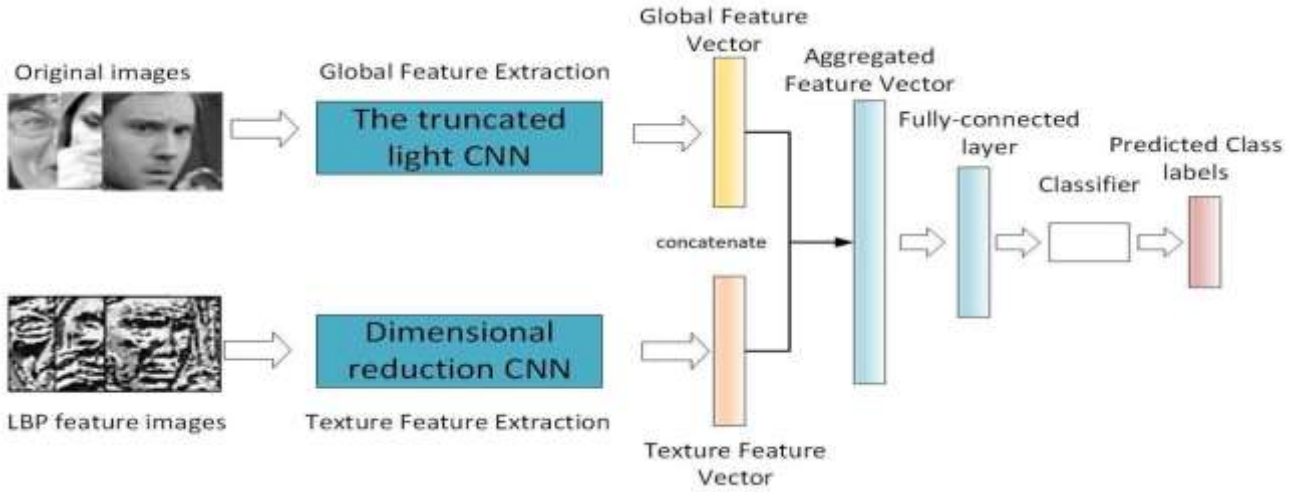

Fig 3.3: CNN Layers

3.4 Working of the model

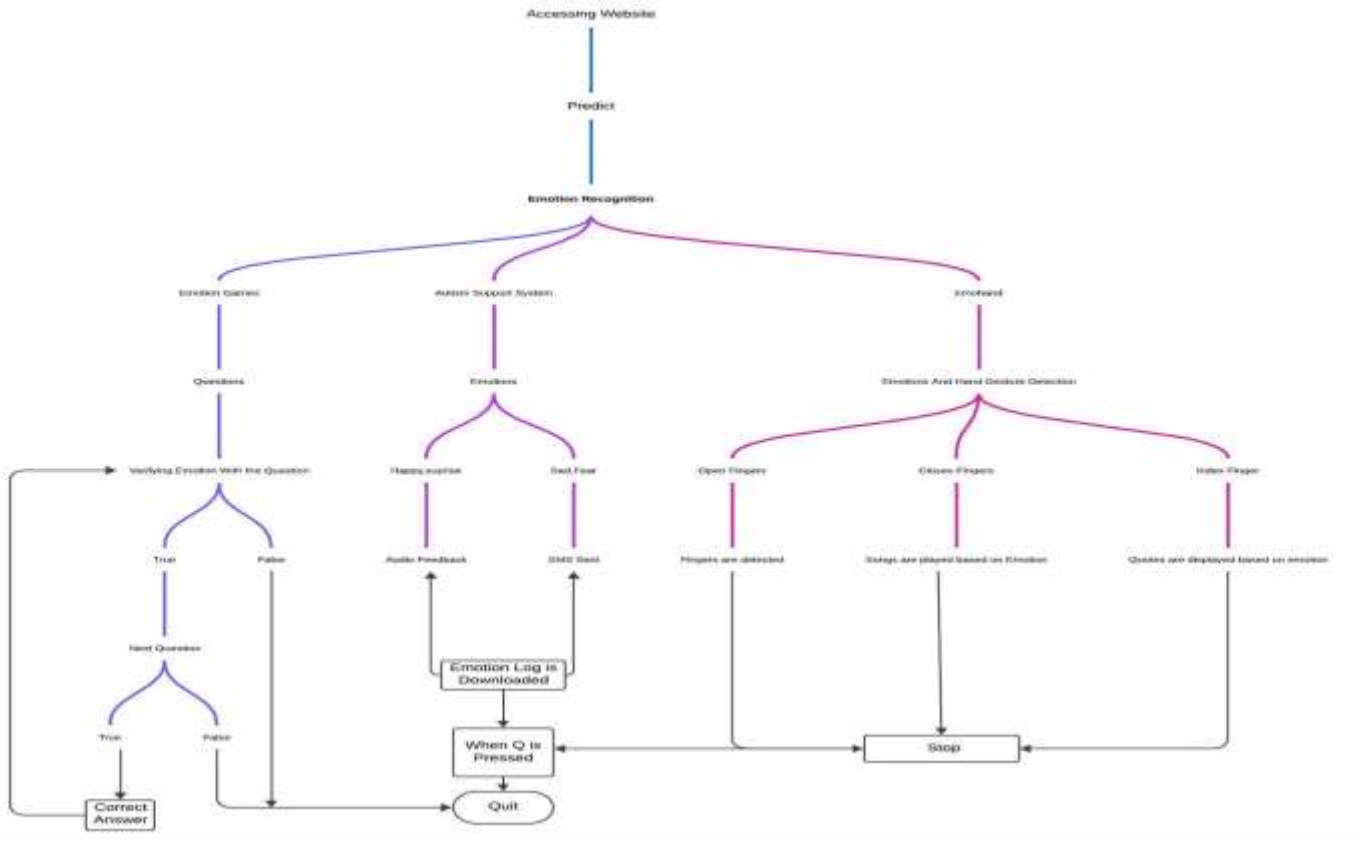

Fig 3.4: Flow Chart of the working Model

IV. RESULTS AND DISCUSSION

4.1 Results of Descriptive Statics of Study Variables:

To provide transparency and reproducibility, we present the working of our model in Table 3. The table represents the various test cases, it's actual and observed results, test analysis, and output features.

Table 1: Descriptive Statistics

Test Case	Expected Result	Actual Result	Observation	Analysis	Output
Emotion Recognition: Happy	System recognizes "Happy"	System recognizes "Neutral"	Failed	Criteria for each emotion need to be updated	Colour of bounding box changes + audio feedback received
Emotion Recognition: Surprised	System recognizes "Surprised"	System recognizes "Surprised"	Performed as expected	Successful	Color of bounding box changes + audio feedback received
Emotion Recognition: Sad	System recognizes "Sad"	System recognizes "Sad"	Performed as expected	Successful	Color of bounding box changes + audio feedback received + Emergency SMS received
Personalized Feedback: Happy	System recognizes	System recognizes	Performed as expected	Successful	None

	"Index Finger"	"Index Finger"			
Session Logging: Save Log	Session log saved successfully	Session log saved successfully	Performed as expected	Successful	None
Notification: Distress Alert	Sends alert for distress	Sends alert for distress	Performed as expected	Successful	None
Notification: Happy State	No alert for happy state	No alert for happy state	Performed as expected	Successful	None

The model firstly displays the UI below. Upon clicking the PREDICT menu, one can find the 3 modules - EmoRecognition, EmoHand, and EmoGame

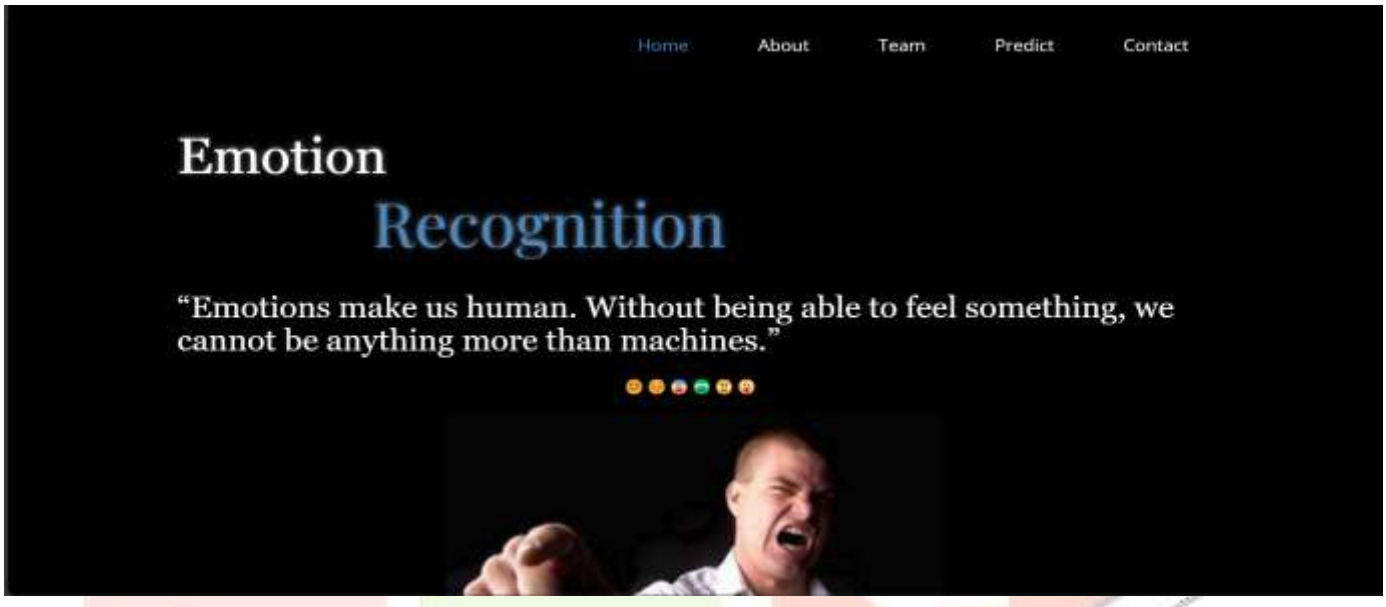

Fig 4.1: User Interface

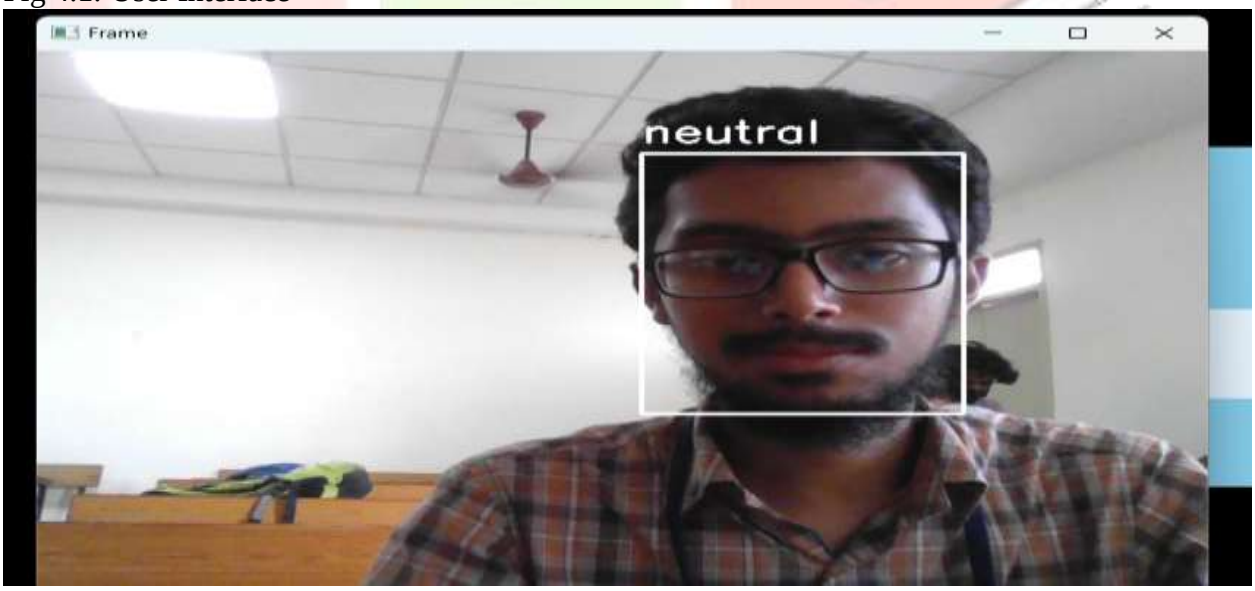

Fig 4.2: Emotion detected in the model

	timestamp	emotion
2	2024-07-1	neutral
3	2024-07-1	neutral
4	2024-07-1	neutral
5	2024-07-1	neutral
6	2024-07-1	neutral
7	2024-07-1	neutral
8	2024-07-1	sad
9	2024-07-1	sad
10	2024-07-1	sad
11	2024-07-1	sad
12	2024-07-1	sad
13	2024-07-1	neutral
14	2024-07-1	neutral
15	2024-07-1	neutral
16	2024-07-1	neutral
17	2024-07-1	neutral
18	2024-07-1	neutral
19	2024-07-1	neutral
20	2024-07-1	neutral
21	2024-07-1	neutral
22	2024-07-1	neutral
23	2024-07-1	happy
24	2024-07-1	happy
25	2024-07-1	happy
26	2024-07-1	happy
27	2024-07-1	happy
28	2024-07-1	happy
29	2024-07-1	happy

Fig 4.3: Emotion Log Of the User for further supervision

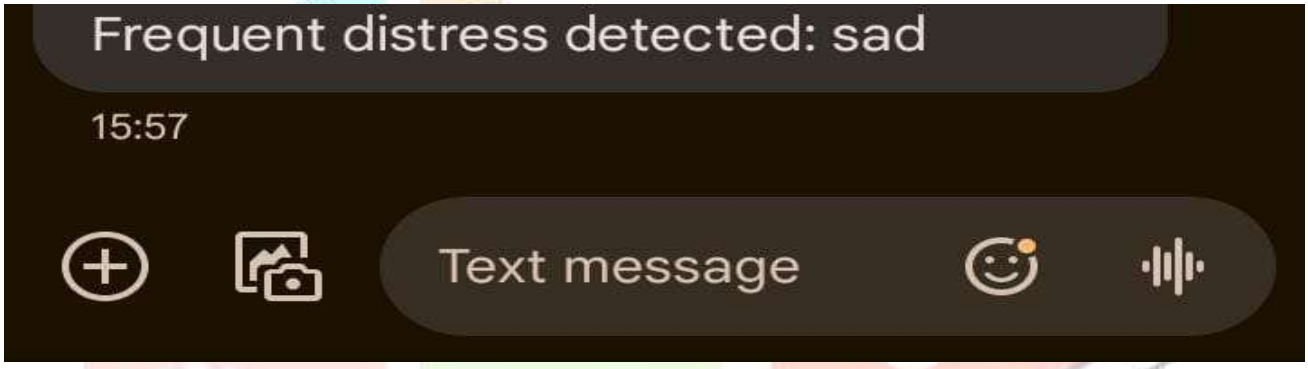

Fig 4.4: Text Message to Supervisor/Parent on Frequent distress detection

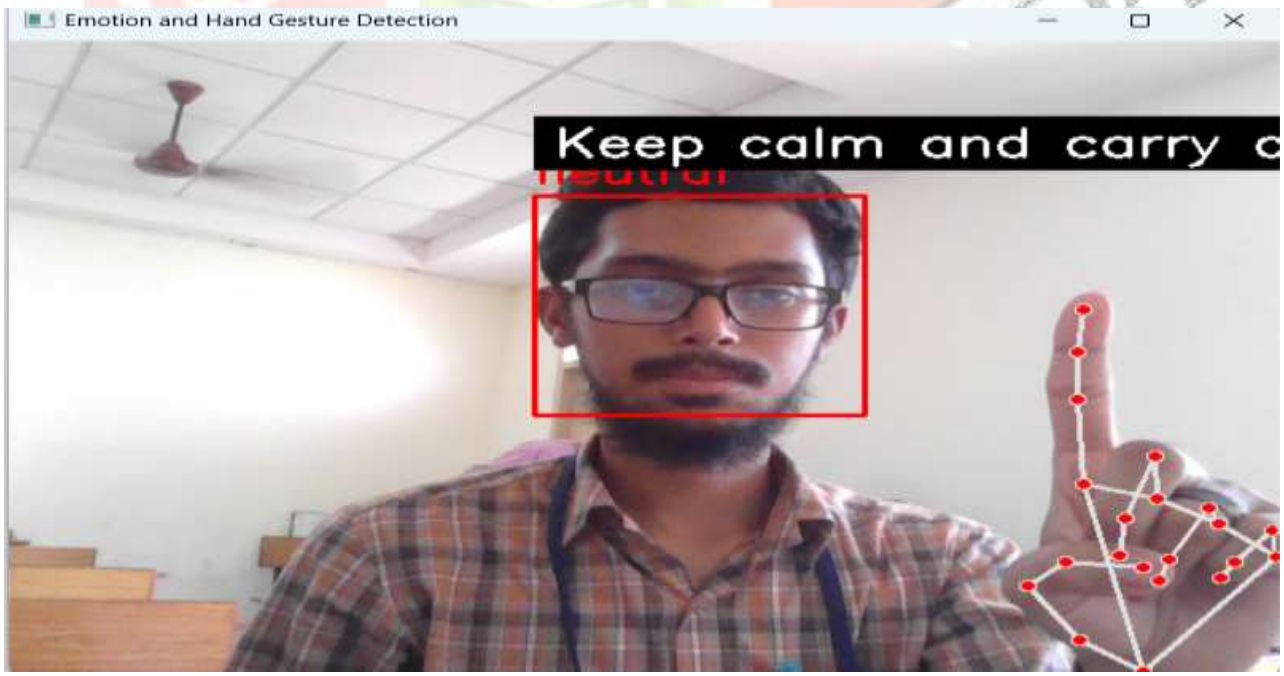

Fig 4.5: Gesture Recognition with personalized feedback and emotion detection with customized songs

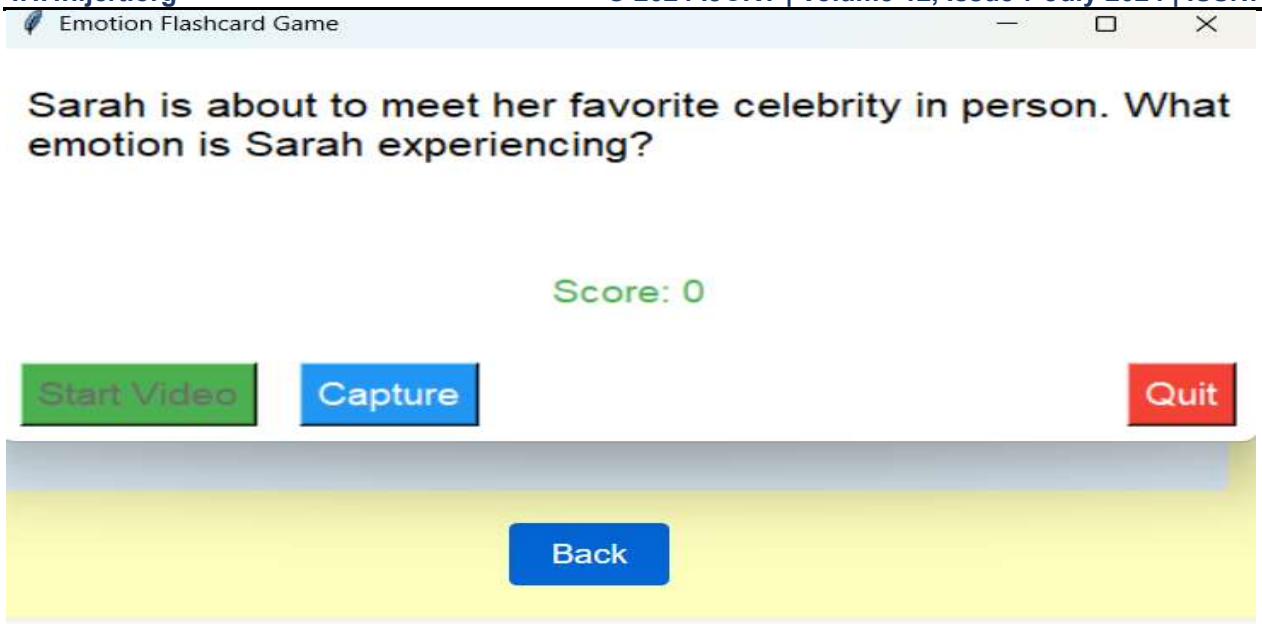

FIG 4.6: EMOTION GAMING

4.2 Future Scope

The Autism Support System has immense potential for future enhancements and expansions. Some areas for future development include:

- Advanced Emotion Recognition
- Contextual Understanding: Improve emotion recognition by incorporating contextual data such as voice tone and body language.
- Multi-Facial Analysis: Enable recognition of multiple faces simultaneously to understand group dynamics and interactions.
- Gesture Recognition: Implement 3D cameras and depth sensors to accurately capture and interpret more complex gestures.
- Personalized Gestures: Allow customization of gestures specific to individual needs and preferences.
- Integration with Wearable Devices: Integrate with wearable devices to monitor physiological data such as heart rate and skin conductance, providing a more comprehensive understanding of the user's emotional state.
- Mobile Accessibility: Develop mobile applications to allow real-time support and monitoring on the go.
- Adaptive Learning: Implement adaptive learning algorithms to tailor game difficulty and content based on the child's progress and needs.
- Multiplayer Options: Introduce multiplayer games to encourage social interaction and teamwork among children.
- Parental/Guardian Dashboard: Create a dashboard for parents or guardians to monitor the child's progress and receive notifications and insights.
- Educational Modules: Develop educational modules to assist with learning and cognitive development.
- Continuous Learning: Implement continuous learning capabilities where the system can improve its accuracy and effectiveness over time based on user interactions and feedback.

- Advanced AI Techniques: Utilize advanced AI techniques such as deep learning and reinforcement learning to enhance system performance.

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